Engineering 340

Final Report

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Snobike

Team 16

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Executive Summary

Sustainable designs have become a growing trend in society today as focus in design has shifted to protecting and preserving the environment. One of the ways that this idea has been demonstrated is through the continued reform in the transportation industry. Biking is an excellent option for those who wish to travel sustainably, but relies heavily on seasonal weather conditions. In order to provide a solution to the problem, the idea for a bike with snow capabilities was created.

The prototype design includes a ski attachment and a tread system. The ski attachment provides additional stability to the rider when turning; as the edges of the skis have the ability to dig into the packed snow or ice, or when in deep snow, as the additional surface area of the skis will prevent the bike from sinking into the snow. The front tire remains on the bike to allow the rider to easily ride in and out of snowy areas. The tread system provides additional traction for the bike in winter conditions. The system is comprised of a snowmobile tread, a tightening system, and tensioning rods, which all work together to keep the tread system on the ground and propel the rider through winter weather conditions.
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1. **Introduction**

1.1. **Team Description**

Snobike consists of four passionate senior Mechanical Engineering students that came together as a team looking to design a product that would have a practical mechanical application and fill a need in the community. Senior Design is a class in which all of what has been learned during the four years at Calvin College can be brought together into one project. It is an opportunity to exemplify all that has been learned and to test the engineering abilities of the team.

![Figure 1: (Left to Right) Matthew Milan, Matthew Brouwer, Jen Meneely, Justin Karsten](image)

1.1.1. **Matthew Brouwer**

Matthew was born and raised in Fresno, California and graduated from Fresno Christian High School. He is a senior engineering student with a mechanical concentration and mathematics minor. Matthew has had two internships, both with the Michigan Department of Transportation. After graduation, Matthew plans to continue is education and pursue a Master’s degree at Purdue.

1.1.2. **Justin Karsten**

Justin grew up in Hudsonville, Michigan and graduated from Hudsonville Public High School. He is currently a senior at Calvin College pursuing a BSE degree with a mechanical concentration. Justin enjoys playing water polo, hunting, snowmobiling, and spending time with friends and family. Upon graduation, he plans to find a job in the Grand Rapids area that fully utilizes his engineering degree.
1.1.3. Jen Meneely

Jen grew up in Pittsburgh, Pennsylvania and graduated from Trinity Christian School. She is a senior engineering student with a mechanical concentration and mathematics minor. Jen has had two internships with Westinghouse Electric Company—in Pittsburgh—and plans to work there after graduation. When not doing homework, Jen enjoys playing volleyball, downhill skiing, and spending time with her family.

1.1.4. Matthew Milan

Matthew was raised in Rockford, Michigan where he graduated from Rockford Senior High School with honors. He is currently working on his BSE mechanical concentration degree at Calvin College with minors in Computer Science and Mathematics. After graduation, Matthew plans to find a job in the Grand Rapids area.

1.2. Problem Statement

The senior design team is proposing to design a bike that will function on both clear and snow-covered trails. The proposed bike will have skis for stability and steering and a tread system that will be powered by the rider. The rider will then be able to use the bike on roads and trails that are covered in snow. By following a minimal number of easy steps, the rider will be able to attach the kit to any standard mountain bike.

The proposed bike will benefit many, especially in the Calvin community. Many in the Calvin community use bikes as their main mode of transportation. By allowing people to ride on snow, more people in the Calvin community will be able to use their bikes during the winter and reduce their dependence on motor vehicles. The rider will save money over time, as well as contribute to a much cleaner earth.
2. Design Considerations

2.1 Project Objectives

2.1.1 Purpose of Design

The purpose of the senior design project is to design and prototype a human powered bike with snow capabilities. The design will be based on a mountain bicycle and will allow for safe travel when there is snow on the ground.

The specific objectives for the project include several changes to the mountain bicycle. Most importantly, the design must be safe and allow for secure and reliable transportation in extreme conditions. The design should focus on travel in snowy conditions, but also allow the rider to travel on clear paths. The bike should not be significantly more difficult to pedal than a regular mountain bicycle, should have similar tolerances, and should be comfortable for the rider.

2.1.2 Cost

The standard senior design budget for each team is $300 and the goal of the team is to stay within the constraint. However, in order to make a product that is considered “well-built” and well designed it was necessary to obtain more funds. The team was awarded a $450 budget. When producing the product in bulk for resale, it is estimated that overhead and manufacturing costs for one bicycle kit would be $150. The competitor’s product costs $529, and an ultimate goal would be to produce the kit for a similar price. The estimates are preliminary, and more market research is necessary to confirm the prices.

2.1.3 Reliability

The design and prototype focuses on people who would be interested in using the product as a commuter vehicle. The bicycle kit must be reliable and trustworthy for everyday commuting during hazardous winter months. The goal of the design was to be simple and efficient, which lead to fewer complicated mechanisms and fewer opportunities for design failure.

2.1.4 Scope

The scope of the design project is a very important objective that must be clearly defined. Although there are many possibilities for the production capacity of the design, the scope will be limited to something that would be of interest to the average bicycle commuter in Grand Rapids. The bicycle needs to be affordable, simple, and efficient. The final design will consist of a kit that can be attached to a regular mountain bike and perform well on both snow and pavement.
2.2  Design Norms

Christian engineers are called by God to adhere to higher standards, which must be incorporated into the designs. These designs and products must be reliable and helpful. People will judge the team based not only on the design, but based on how they conduct themselves throughout the design process and use that a representation of the team’s Christianity. The team has decided to adhere to the following design norms that they believe best demonstrate the goals of the product.

2.2.1 Stewardship

The Snobike team is committed to stewardship, both financial and environmental. The project provides commuters who bike to work in the summer to have the option to bike year round. The proposed bike will reduce the number of cars on the road and provide an eco-friendly way to get to work, reducing emissions and promoting sustainability. The bicycle design will be less expensive than a car, not only in initial price, but also in annual maintenance costs, providing the commuter with a considerable savings when choosing to bike.

2.2.2 Transparency

The kit must be consistent, reliable, and predictable. The Snobike kit must function in snow and sleet and must keep the rider safe. If the designers have an open communication about the design, then the user will better understand the concepts behind the work and will be able to rely on the consistency and the stability of the bicycle and the kit. Transparency is important in a kit design because the user must be able to understand how to put the kit together in order to apply it to their bike and be able to modify or make repairs as necessary.

2.2.3 Trust

The kit design is dependent on the trust of the user. If the user does not trust the design of the kit, they will not use it or be interested in purchasing it. The incorporation of trust into a design makes it dependent and reliable. Trust also means avoiding conflicts of interest. No questionable choices or design features that might bring harm to the user.

2.3 Alternative Solutions

There are several alternatives to using a Snobike. One option is to use a regular mountain bike in the winter. However, regular mountain bikes have a limited amount of traction in the snow, causing difficulties in forward motion and turning. Another alternative is walking, which takes longer and has an extended exposure time to harsh weather conditions. A third option is to drive a car, which is the most costly alternative and is harmful to the environment because it consumes fossil fuels. Driving a car is also very dangerous in the winter and the chance of getting in an accident is greatly increased with slippery roads.
3. Project Organization

3.1. Schedule

3.1.1. Major Deadlines

Major deadlines can be seen in bold below in Table 1.

3.1.2. Task Breakdown

The task breakdown for specific class assignments and team goals is listed in Table 1.

Table 1: Schedule and Task Breakdown Chart

<table>
<thead>
<tr>
<th>Item</th>
<th>Assigned to</th>
<th>Date Due</th>
<th>Status</th>
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<tbody>
<tr>
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<td>Team</td>
<td>2/10/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Website Upgrade</td>
<td>Matt M</td>
<td>2/19/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Industrial Consultant Report</td>
<td>Matt M/Justin</td>
<td>3/1/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Business Plan</td>
<td>Team</td>
<td>3/3/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Class Presentation</td>
<td>Matt B/Jen</td>
<td>3/3/2010</td>
<td>Complete</td>
</tr>
<tr>
<td>Friday's Poster</td>
<td>Jen</td>
<td>3/10/2010</td>
<td>Complete</td>
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<td>3/17/2010</td>
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<tr>
<td>Order Parts</td>
<td>Team</td>
<td>3/18/2010</td>
<td>Complete</td>
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<td>Initial Prototype</td>
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<td>Banquet Description</td>
<td>Jen/Justin</td>
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<td>4/9/2010</td>
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<td>Second Prototype</td>
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<td>Prototype Testing</td>
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<td>Third Prototype</td>
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<td>4/14/2010</td>
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<tr>
<td>Prototype Testing</td>
<td>Team</td>
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<tr>
<td>Draft Design Report</td>
<td>Team</td>
<td>4/19/2010</td>
<td>Complete</td>
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<td>CEAC Review</td>
<td>Team</td>
<td>4/23/2010</td>
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<tr>
<td>Touch-ups to Prototype</td>
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<td>4/28/2010</td>
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<td>Draft Design Report Faculty Review</td>
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<tr>
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<td>Matt M</td>
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<tr>
<td>Notebook Due</td>
<td>Team</td>
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<td>Complete</td>
</tr>
<tr>
<td>Final Design Report Due</td>
<td>Team</td>
<td>5/12/2010</td>
<td>Complete</td>
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</table>
3.2. **Task Delegation**

Snobike consists of four equal team members. In January of 2010, the decision was made that Matthew Brouwer and Jen Meneely would focus most of their energies on design of the ski system while Justin Karsten and Matthew Milan would focus on the design of the rear tread system. However, for major design decisions and in discussion of concerns, the entire team will contribute to the resolution of the issue.

3.3. **Testing**

All team members were present and involved in testing situations. It was the most effective way for the team to determine the methods of testing and what aspects of the bike needed to be tested more than others. In most situations, all team members would have the opportunity to ride the bike and then work together to troubleshoot potential issues or attempt to solve problems that arose during testing. This situation was an opportunity for the entire group to be on the same page in design and operation and goals for the project.
3.4. **Final Budget**

The final budget for the project is in Table 2. The final amount spent by the team was $296.34.

**Table 2: Final Budget**

<table>
<thead>
<tr>
<th>Item</th>
<th>Dimensions</th>
<th>Price Per Unit</th>
<th>Total Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threaded Rod</td>
<td>3/8&quot; Diameter</td>
<td>$5.27</td>
<td>$5.27</td>
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<tr>
<td>Skis</td>
<td>N/A</td>
<td>$8.47</td>
<td>$8.47</td>
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<tr>
<td>Nuts and Bolts</td>
<td>N/A</td>
<td>$6.40</td>
<td>$6.40</td>
</tr>
<tr>
<td>Quick Release Lock</td>
<td>N/A</td>
<td>$6.35</td>
<td>$6.35</td>
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<tr>
<td>Bike Seat Clamp</td>
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<tr>
<td>Clamps</td>
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<td>$1.53</td>
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<tr>
<td>2 U-Clamps</td>
<td>5/16&quot; by 4-3/8&quot;</td>
<td>$20.48</td>
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<tr>
<td>Steel 304 Tube</td>
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<td>Threaded Aluminum Rod</td>
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<td>Shocks</td>
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<td>$20.00</td>
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<td>Shock Connectors</td>
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<td>6-7-8 speed</td>
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<td><strong>Percent Used</strong></td>
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</table>

3.5. **Production Costs**

The cost of the product is different than the budget shown in the table above. Some of the materials used in creating the prototype were donated or taken from the metal shop; however the cost of these materials is still accounted for in the final cost of the product. Refer to the appendix for a complete bill of materials. The cost to purchase the materials is $343.86, which does not take bulk purchasing or manufacturing costs into account.

3.6. **Business Plan**

Refer to the appendix for the proposed business plan for the product.
4. Ski Design

4.1. Final Design

![Ski Mechanism](image)

**Figure 2 : Ski Mechanism**

4.1.1. Ski and Ski Connection

The connection to the downhill skis used for prototyping the design was based on a 1.5 inch wide U channel. The downhill skis were cut to a length of 22.375 inches and holes were pre-drilled into the skis, allowing the aluminum U channel to be centered and attached with 0.212 inch diameter, self-tapping screws. The 1 inch aluminum bar that connects the skis to the bike was then attached to the U channel with a 0.4375 inch diameter bolt through the two sides of the channel with the bar placed inside the channel. The skis can pivot about this bolt. A spring loaded system was added to hold the skis parallel to the ground. The spring allows for the front of the skis to lift but will pull it back to its original parallel position. A stopper was welded to the main vertical bars to constrain the skis from pivoting further than back to the original position.
The skis were attached to the bike parallel to the ground on either side of the tire, 1.75 inches above the ground. The placement of the skis also takes the distance from the tire into consideration to determine the possible turning radius before the skis make contact with the ground. If the skis were moved closer to the tire, the system would need to be lowered in order to achieve the same turning radius. However, it was determined that moving the skis even 0.25 inches lower would cause the skis to be in direct contact with the tire, which was undesirable. The placement of the skis allows for a “training wheel” effect of the skis on the tire. If minimal covering or packed snow is on the roads, the skis provide additional stability and turning for the rider. The rubber tire is relied upon until an unsafe turning radius is achieved. The edge of the ski will come in contact with the ground and provide the “training wheel” effect along with an ice cutting edge. When a lot of snow is on the ground, they provide a large amount of surface area, stability, and guidance for the bike with the tire acting as a rudder. The surface area helps keep the front tire from getting bogged down in the deep snow. If the roads are clear of snow, then the skis are not involved in the operation of the bike, providing the versatility necessary for an everyday rider.

4.1.2. Axle Attachment

The ski mechanism was designed so the original quick release front axle could still be used. The 1.95 inch thick spacer nuts on the original axle were removed to create space for the tabs from the ski mechanism. The aluminum bar of the ski mechanism is welded to these tabs allowing the main bars to be perpendicular the ground. The aluminum bar continues through the welded plates and is connected to the ski mechanism above the tire. The tabs were slotted to allow ease of assembly.
4.1.3. Upper Fork Mechanism

The mechanism that connects the two aluminum bars to the top of the forks of the bike is a machined piece of aluminum 1 inch thick.

The mechanism has a dowel attachment with a threaded rod that attaches to the fork of the bike. The two 25 inch high bars are welded in the slots machined in the mechanism to provide the strongest support for the ski attachment.
Figure 6: Welded Bars to Mechanism

The 6.375 inch long and 0.3125 inch diameter threaded rod attaches the entire system to the brake fender of the bike. The connection creates the reaction moment to keep the mechanism from rotating, bringing additional strength and stability. The connection shown in Figure 7 demonstrates how the mechanism attaches to the top of the bike.

Figure 7: Fender Attachment
4.2. Important Design Considerations

4.2.1. Universality

One of the biggest challenges with the project was the kit design. The kit has to be attachable to any mountain bike, meaning that no modifications could be done to the prototype bikes that were permanent. All design additions were relatively easy to remove and attachable to any bike without drilling or welding. If the kit design had not been a stipulation to the project it would have been significantly easier to attach the skis, however the product would not have been as advantageous or as marketable.

4.2.2. Front Tire

In the competitor’s design, the front tire is removed.

![Figure 8: Competitor’s Front Ski Design](http://www.ktrakcycle.com/)

A design option similar to the competitor’s model was impossible for the Snobike team to follow because of the commitment to a commuter-friendly product. Removing the front tire would not allow the user to ride on concrete/asphalt without removing the ski attachment and reattaching the front tire. Carrying around either a ski system or a front tire while the other piece was in use would not be a simple design or convenient for the user. The end result, skis that act like “training wheels,” is most convenient for the user, as no adjustments need to be made to the bike when riding on and off snow-covered paths.

4.2.3. Stability and Safety

The safety of the bike is linked to the stability of the bike and the rider. If the rider does not trust the bike to be stable and to provide safe transportation, then they will not use the product or recommend the product to others. Safety was an integral part of the design, the first few prototypes of the ski system were not entirely safe and certainly not marketable, and it was in the best judgment of the team to continue to strive to a safer, more reliable design.

4.3. Design Methods

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1 http://www.ktrakcycle.com/
4.3.1. Finite Element Analysis

It is important to maintain the structural integrity of the current user’s bike. The Snobike kit should in no way damage the mountain bike that the user has.

4.3.1.1. Assumptions

The original axle is used, and therefore is not an area of concern. It has been designed to withstand appropriate forces. Any force transmitted to the axle from the tabs of the ski attachment will not damage the axle or the bike frame. A major area of concern is the attachment of the ski mechanism to the brake fender. This is the most likely spot damage would be caused by the Snobike kit.

4.3.1.2. Brake Fender

FEA was done on the brake fender component to determine whether it would yield. A 200 pound force was applied to where the threaded rod is attached to the fender. The welds were held fixed. The results can be seen in Figure 9.

![Figure 9: Brake Fender Stress Analysis](image)

A maximum stress of 53.6 ksi was achieved which is below the yield stress of 53.7 ksi for AISI 1018 steel. A 200 pound force is also quite conservative as most of the time it is not possible to apply a force to the fender. If the skis are struck, the angle of pitch of will increase. The tire will then come into contact and absorb the force as normal. Also, the attachment to the fender is to fix
the rotation around the axle. Rotation is already hindered by the fact that the axle is in compression on the tabs of the ski assembly. This compression will decrease the applied force to the fender. With a 200 pound force, the threaded rod will not reach yield as the stress is only 2.6 ksi.

4.3.1.3. Ski Attachment Tabs

Another area of concern was the ski attachment tabs. The tabs attach the ski mechanism to the axle. Much of the force of the skis would be transferred through the tabs to the axle and frame. A 300 pound vertical force and a 40 pound horizontal force were added to simulate what happens when a ski comes into contact with the ground while turning the bike. These forces are conservative as the force distribution of a 200 pound rider results in a force on the front tire of only 43.9 pounds. The results can be seen in Figure 10.

![Figure 10: Axle Tab Stress Analysis](image)

Under these conditions, a maximum stress of 38.1 ksi was achieved which is below the yield stress of 40 ksi for Aluminum 6061 T6, so the tab will not yield. The results for the tab FEA were verified with hand calculations which can be found in the appendix section Tab Hand Calculations.

4.3.1.4. Ski Stopper

Another area of concern was the stopper constraining the range of motion of the ski. When going off a curb, the back of the skis may come in contact with the curb and apply a force to the stopper. This force was assumed to be 50 pounds. This number is conservative as 43.9 pounds of a 200 pound rider is held by the front tire, and this would be distributed between 2 skis. Also, the ski will only skip off the curb as the rider goes off of the edge of the curb. Another 100 pound force was added to the side of the stopper and accounts for possible eccentricities of the stopper.
A maximum stress of 25 ksi was achieved which is below the yield stress of 40 ksi for the Aluminum 6061 T6 that was used.

4.3.2. Prototyping

The primary design method for the ski system was prototyping. The team had limited knowledge of the mechanics behind bike and ski design and how these worked together, so it was important to test a variety of ideas in order to best understand the situation. A variety of models were tested and it was determined that the best model was one where the edges of the skis were utilized to assist in turning while the flat bottoms of the skis were employed to keep the bike from getting caught in deep snow.

4.3.3. Testing

Testing was a difficult task after the snow melted. It is fortunate that some testing was done in late February, and several videos were taken of the testing process. However, after the snow melted, it was difficult to find materials that performed similar to snow in order to ensure that the final design was the best design. The team determined that sand was a relatively comparable material to snow for modeling how the skis would react. Many tests were done in sand throughout the ski design process, especially in late March and April. Figure 12 demonstrates the final ski design turning in the sand.
4.4. Other Tested Models

The process of designing the ski system was not a simple or straightforward one. Retro-fitting a bike with new parts that it was not initially designed to include was a complicated process. Several different, working models for the ski system were built from the prototyping process. The models were gradually optimized to the final prototype. However, if the product were ever to be produced, further optimization and polishing should be considered.

4.4.1. Initial Design

The initial design had the skis clamped to the outer edge of the forks of the bike and attached via a lengthened axle. The skis were lowered to be roughly an inch below the tire—meaning the front tire was hanging above the ground. There were a few main difficulties with the design. First, there was no ability to ride on pavement without stopping the bike and getting off to raise the skis. Second, the extended connection to the axle would need to support the weight of the rider and any additional impact force the bike would undergo. Third, turning was difficult as it was only possible to turn on one edge of the inner ski, which caused imbalance. The team decided to continue pursuing a better design.

4.4.2. Prototype 2

The modification to the second prototype was to raise the skis to half an inch above the bottom of the tire. The tire now acted like a rudder, allowing the skis to guide the tire through snow. The aluminum bars were still clamped to the forks of the bike and connected through the lengthened axle. The issue with the second prototype was the idea of universality. The angle of the forks on every bike is different, meaning the skis would be at a different angle on every bike and the user would need to make the necessary adjustments. The team felt the system could be constructed a better way and decided to continue the optimization process.
4.4.3. Prototype 3

After discussion with the team’s industrial consultant, Dr. Ren Tubergen, the team decided to take the design in a different direction. The skis were constructed with their own set of forks, connected to the axle and over the top of the front tire. The skis were installed at a 15° angle creating a “training-wheel” type feel and allowing the front tire to act like a rudder and the skis to support it. However, after testing, it was determined that the skis did not provide support, but allowed for additional slippage. The user would attempt to lean into a turn on the bike, the ski would hit the ground, and then the entire system would slip. The third prototype was the last step to the final prototype, in which the skis were parallel to the ground, as discussed earlier.
Figure 14: Prototype 3 with Angled Skis
5. Tread Design

5.1. Final Design

The tightening system design has included much of the original bike design. For example, the rear wheel is a functioning part of the design. The tread is propelled by the back rim, which is connected to the current pedal-chain gearing system. An idler wheel is connected to the bike’s rear axle with a simple tightening system. The tightening system is composed of a steel tube and a threaded aluminum rod. The tube slides over the rod and is held in place with a large steel nut. The nut can then be moved along the threaded rod to change the length of the tightening system.
5.1.2. Alignment

The alignment aspect of the tread design is crucial to the bike’s overall functionality. The tread maintains its alignment at both the rear bike wheel and the idler wheel. The rear wheel of the bike has the rubber tire and tube removed, allowing for the tread to interact directly with the rim. The tread has rubber teeth that are forced into the groove of the rim as the tread rides over the wheel, which ensures that the tread will not slip off of the back wheel during operation. The idler wheel consists of two small steel wheels that have a flat, rubber surface. The separation in the wheels allows the rubber teeth to easily pass around them.

Figure 16: Tightening System

Figure 17: Alignment
5.1.3. Shock System

The shock system was developed after the initial test of the tread system. A downward force was needed on the back idler wheel to help maintain traction in the snow on uneven terrain. Without the downward force, the tread system is inefficient. Through testing, it was determined that the weight of the idler wheel provides adequate force for level terrain. The shocks allow the tread to be engaged when the Snobike is going over uneven terrain. In addition, the shock system helps to stabilize the tread system ensuring that the idler wheel does not swing up and strike the user. Two gas shocks, each with the capacity of 35 pounds of force, were implemented in order to reduce weight and provide a consistent downward force. The shocks are attached to the bike below the seat. The opposite ends of the shocks are connected to steel rods, which are welded to the steel tubes at a 60 degree angle.

Figure 18: Shock System

5.1.4. Tread

The tread was developed to enable the user to have adequate traction in the snow. The tread is 1.75” wide and has a triangular rib pattern along the outside to better grip the snow. The rubber teeth (0.72” x 1.1” x 0.55”) along the inside of the tread keep the track aligned and secure. Currently, these teeth are too wide to fit in all rims. Since the tread will be custom made, the rubber teeth will be 0.5” wide. Cushion will also be added to ensure that the rim is not damaged, this tread design is discussed in the future work section. The tread has been cut to be as wide as an average mountain bike tire, which ensures the tread is thin enough to move freely through the rear of the bike while wide enough for the rim to ride on the rubber.
5.2. **Important Design Considerations**

5.2.1. Universality

The product is intended for use on any mountain bike, which makes the product more marketable and easier to understand. Universality was a main goal of the project, bringing additional constrains on the design and function of the kit. In the tread design, universality issues were encountered when designing attachment points and determining the capability. The Snobike kit does not have any permanent attachments to the bike, meaning there is no need to weld or bolt the kit to the bike itself. Universality also came into play with compatibility. The Snobike kit needs to be able to accommodate the differences in the many variations of different styles and brands of mountain bikes. The design was constrained to become simpler and more streamline and simpler solutions leave less possibility for complication and interference.

5.2.2. Material Selection

The kit should be as lightweight and inexpensive as possible while still performing properly. When the initial prototype was created, it was completely made of steel. Steel was chosen because scrap was widely available. Once the initial prototype proved the concept, the material selection began. A Finite Element Analysis was performed to determine if steel components of the system could be replaced with aluminum. It was determined that only the threaded rod and its connecting plate could be changed to aluminum. It was also found that the tube could be changed to lightweight steel. A further description of the method can be found in the Finite Element Analysis section below.

5.3. **Design Methods**

5.3.1. Finite Element Analysis
Finite Element Analysis was a very important tool in the design of the tread system. The main components of the tread system (Tubes, Idler Side Plate, and both Tire Side Plates) were modeled in Inventor® and imported into an FEA program. Then, the constraints and maximum expected forces were determined. A maximum tightening force of 200 pounds per side (400 pounds total) was chosen for the analysis because it is about twice the force expected during normal operation. This was done to ensure the design could withstand any extreme variations of use by the consumer and to create a more reliable product. A 35 pound force from the shocks (at a 60 degree angle) was also applied to the tubes. The change in horizontal force was also added to the various plates during analysis. The table below lists the results of the Finite Element Analysis.

**Table 3: FEA Analysis of Tread System Components**

<table>
<thead>
<tr>
<th></th>
<th>Loading</th>
<th>Max Stress (psi)</th>
<th>Strength (psi - Ult. / Yield)</th>
<th>Percent of Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tubes - T304 Stainless Steel</strong></td>
<td>200lb on Tube, 35lb adjustment bar</td>
<td>12189</td>
<td>73200</td>
<td>16.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>31200</td>
<td>39.07</td>
</tr>
<tr>
<td><strong>Idler Side Plate - 2024 T4 Aluminum</strong></td>
<td>200lb force, 35lb adjustment bar</td>
<td>1316</td>
<td>64000</td>
<td>2.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42000</td>
<td>3.13</td>
</tr>
<tr>
<td><strong>Tire Side Plate (With Hook) - AISI 1010 Steel</strong></td>
<td>200lb force, 35lb adjustment bar</td>
<td>10681</td>
<td>47100</td>
<td>22.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>26100</td>
<td>40.92</td>
</tr>
<tr>
<td><strong>Tire Side Plate (No Hook) - AISI 1010 Steel</strong></td>
<td>200lb force, 35lb adjustment bar</td>
<td>1098</td>
<td>47100</td>
<td>2.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>26100</td>
<td>4.21</td>
</tr>
</tbody>
</table>

**5.3.1.1. T304 Stainless Steel Tubes**

The tubes were fully modeled and analyzed. The slot for the plates was modeled and held in a fixed position during analysis. The end of the tube had a 200 pound compression force applied parallel to the tube. The holes for the shock bars were also modeled, and a 35 pound force for each shock was modeled at a 60 degree angle. Figure 20 shows the FEA results for the full tube.
Figure 20: Full Tube Assembly

No large areas of stress along the tube can be seen from this view, and the average stress is around 2400 psi. However, there were a few points that had a spike in stress, peaking at around 12,000 psi.

Figure 21: Peak Stress near Plate and Slot in Tube

Figure 21 shows a better view of the peak stress near the plate slot. The peak stresses were compared with several types of steel. It was determined that the max stresses calculated were only 39% of the strength of T304 Stainless Steel. Stainless steel is inexpensive and lightweight, and was an ideal choice for use in making the tube.
5.3.1.2. 2024 T4 Aluminum Idler Plate

The plate that attaches the threaded rod and idler wheel axle was also modeled in FEA. The axle hole was kept fixed, while a 218 pound force was applied to the end of the plate. The force accounts for the tightening force and the maximum shock force that could be encountered. Figure 22 below shows the stresses in the idler plate.

![Figure 22: Stresses in the Idler Side Aluminum Plate](image)

The maximum stress encountered was 1,300 psi. With such a low stress, 2024 Aluminum T4 was chosen as the plate material. 2024 Aluminum T4 is lightweight, inexpensive, and capable of handling the expected stresses. The maximum stress encountered was 4,330 psi, which was only about 8 percent of the steel’s yield strength, proving it was strong enough for use in the tread system.

5.3.1.3. AISI 1018 Tire Side Plate with Hook

The tire side plate was designed completely from Finite Element Analysis. Strong steel was necessary for this component leading to the choice of AISI 1018 steel. With material properties for this steel readily available, it was simple to design and analyze the plate. The key to reducing the stress was to ensure the distance between the top of the plate and the cutaway arc was large enough without adding too much extra weight or unnecessary material. For the analysis, a 181 pound force was applied to the end of the plate, while the axle hole was held fixed. The force accounts for the tightening force and the shock force. Figure 23 shows the final design and stresses in the plate.
5.3.1.4. AISI 1018 Tire Side Plate without Hook

The other tire side plate was modeled and analyzed. The plate has a simple square shape. The axle hole was kept fixed, while a 181 pound force was applied to the end of the plate. This accounts for both the shock and tightening forces. The full analysis is shown in Figure 24. The maximum stress encountered was about 1100 psi, which is less than the yield strength of the AISI 1018 steel, ensuring that the plate would not fail.

5.3.2. Other Calculations

5.3.2.1. Threaded Rod

The threaded rod was not modeled using Finite Element Analysis, but calculations were performed in order to ensure the success and reliability of the rod design. Using standard thread
equations shown below, it was determined that a 200 pound force would lead to a 210 psi stress on the threads of the 0.75 inch diameter rod. This is much lower than the yield strength of aluminum, which is about 31,000 psi. From the calculation, it was determined that the rod would be sufficient and was included in the final tread system design.

\[ \sigma = \frac{4P}{\pi(d^2-d_1^2)} \times \frac{p}{t} \]  

(1)

5.3.2.2. Force Distribution

The force distribution along the tread is critical to the overall functionality of the kit. If there is no downward force on the tread, there can be no movement. The force moment equations:

\[ M_a = 0[\text{lb} * \text{in}] \]  

(2)

\[ M_a = F_b \times d_b + F_c \times d_c \]  

(3)

(where \( M_a \) = moment about a, \( F_b \) = force at b, and \( d_c \) = distance from a to c) were used to calculate the distribution of force along the two rigid points of the bike (the front and back wheel). These calculations show that a 200lb person would create 156lb of downward force at the rear wheel. There would also be a 7.5 pound force at the idler wheel from the weight of the idler wheel and arms. There is little to no force acting on the tread between the rear wheel and idler wheel, mostly because the tread is not rigid. However, the tread between the two wheels provides a key function. This function is to grip any uneven terrain. Since the tread is tightened, it wants to stay even with the bottom of the rear wheel and idler wheel. If the user were to ride over a bump, the tension in the tread would cause the tread to be pressed against the bump, adding traction and ensuring a smoother ride.

5.3.2.3. Tread Force Testing

Another important calculation was the pedal force required to overcome the initial friction force in the tread system. This was done by comparing the relative lengths of the exposed threaded rod to the force required to initiate movement. The force was determined by placing a combination of various known weights on the pedal until movement was achieved. This was done with both no initial rider weight and a rider weight of 200lbs. Figure 25 below shows the testing results.
Figure 25: Increased Pedal Force with Varying Tread Tension

Testing was also done to determine the difference in pedal difficulty with and without the tread attached. This testing shows that, on average, there is a 14 pound increase in the force required to pedal with the tread than with a regular tire. While this may sound like a significant issue, the average force required to pedal with the tread is only about 27 pounds. This is not unreasonable, as it is much more difficult to pedal through snow with a regular tire than the tread system.

5.3.2.4. Shock System

The impact of the shocks on the overall tread system was also calculated. It was determined from testing that a total potential force of 10-15 pounds on the idler wheel would be sufficient to handle any bumps encountered while riding. It was also determined that any force higher than 15 pounds on the idler wheel could cause the tread to come loose during riding. Knowing these values, Engineering Equation Solver (EES) was used to calculate the shock force needed. This Sheet can be found in the appendix. Since shocks are sold in standard force amounts and standard lengths, an exact 10 or 15 pound idler wheel force could not be obtained. Instead, the shocks were chosen based on the idler wheel force that came closest to the 10-15 pound range without going over 15 pounds or under 10 pounds. After some optimization, it was determined that 2 – 35 pound shocks at a 60 degree angle would provide an adequate 12 pounds of force on the back idler wheel. The angle of the shock bars should not exceed 60 degrees in order to provide maximum reliability of the shock system.

The weld stress was also calculated using torsional shear equations. The weld is relatively box shaped, and was modeled as a box in torsion. Using a torque of 659 lbf-in (from a 35 pound shock at a distance of 18 inches), and knowing the dimensions of the weld, the equation
5.3.3. Prototyping

5.3.3.1. Tightening System

The tightening system went through multiple stages during the design process. The first prototype did not have a tightening system, using one solid rod to connect the rear bike wheel and the idler wheel. This did not work because it bent the connecting rod and put torque on the idler wheel because of the lack of symmetry. The next prototype incorporated a solid rod on each side of the wheel; however it was still difficult for the user to put the kit on. It also limited the ability to adjust the tension of the tread so that it was either too difficult to peddle or the tread slipped. The team decided that adjustability was a necessary component of this part of design, and was achieved by implementing the threaded rod and tube system. The user can easily install the tread system and is able to adjust the tread tension to achieve a proper balance between grip and ease of peddling.

5.3.3.2. Shock System

The initial design did not include any type of shock system. However, testing revealed that the full length of the tread was not in continuous contact with the ground, which was inefficient. A downward force was added to the idler wheel, via weights placed on the threaded rod near the idler wheel. Further testing proved that the tread was now fully utilized; establishing a downward force on the idler wheel was necessary. Calculations were done to determine the exact downward force necessary and the shocks were added to the design. The shocks do not apply a constant downward force; rather they counter any upward force from bumps or grooves. The shocks act as a safety mechanism to ensure the idler wheel does not swing up and strike the user. In the continuation of testing, it was determined that the force of the shocks needed to be applied when the tread was flat on the ground. When the shocks are pre-compressed, the back wheel of the bike loses contact with the ground. However, if the shocks are not pre-compressed, no force is applied to the idler wheel. Therefore, the parts involved in this design were carefully measured and machined in order to maintain this delicate balance.

5.3.3.3. Tread Alignment

The tread alignment design went through several changes during prototyping. Initially, the tread rode on the rear bike tire and a single rubber idler wheel. The tread that was used did not have any rubber teeth along the inside. The tread slipped off of the wheels frequently, causing problems in normal operation of the bike. The decision was made that the idler wheel should consist of two rubber wheels. These wheels had a groove that allowed the tread to sink into the wheel and restrict movement. However, the tread still frequently slipped off of the bike tire. A design that utilized the tread’s rubber teeth was created. The tread rides over the bike tire rim as well as the two rubber idler wheels. The tread teeth would be forced into the groove on the wheel rim, restricting side-to-side movement and ensuring the tread was secure. The two idler wheels were spaced so that the rubber teeth passed between the wheels, also restricting side-to-side movement and further securing the tread.

\[ \tau_{\text{max}} = T(3 \times \text{Width}_{\text{weld}} + 1.8 \times \text{Length}_{\text{weld}})/(\text{Width}_{\text{weld}}^2 \times \text{Length}_{\text{weld}}^2) \]
5.4. Prototype Testing

Prototype testing happened in two distinct phases. The first phase occurred in late February, where the basic tread system was tested on the snow. The tread system performed very well on the snow and made it easier to have traction on a slippery surface. However, two problems were discovered. The tread came off the wheels after about 100 feet of riding and no mechanism was in place to prevent or counter loss of traction from bumps. The second phase of testing occurred in April, and the prototype incorporated changes to correct the problems discovered during the initial phase of testing. Including a shock system to counter bumps or cracks and a wider tire to accommodate and prevent the tread from slipping off of the wheel. The final prototype testing was a success; there were no instances of the tread slipping off, and no loss of traction; the shock system quickly countered any unforeseen changes in terrain.
6. **Safety**

Safety was one of the biggest concerns in design and testing of the prototype. The Snobike team did extensive testing to ensure that the kit designed was safe under the expected operating conditions. More testing was done under extreme situations in order to determine the limits of the kit design, however if the product was to be put into production, further testing would need to be done in order to ensure the complete safety of the rider.

6.1. **Ski Limitations**

The skis have been placed 1.75 inches off the ground so that they do not interfere with normal operation. However, when operating the bike on pavement, care should be taken when turning with the skis. If they were to get caught on the pavement, the rider would be in danger of falling over. Through extensive testing, the team has proved that this situation is unlikely; however the rider should be aware of this and take precautions. The ski system is for assistance in snow travel, not for total control in snow travel and the rider still needs to be cautious of winter weather conditions.

The ability of the skis to change pitch is an important factor in design, it gives the rider additional movement area without ski interference, including traveling up and down hills. The pitch also provides a necessary safety factor. If the rider is going at a high speed and crashes into a curb, the skis will be able to deflect upwards, out of the way of the crash. Then, the tire will take the majority of the impact, which is what it was designed to do, and the skis will not be involved.

6.2. **Tread Limitation**

Some warnings may need to be issued in order to ensure safety of riders. The tread does not currently have a safety guard. Therefore, body appendages should be kept away from the moving tread as they may get caught in either the rim or idler wheel. Also, one may not stand on the idler arms as this may damage the kit. Also, currently the tread is quite long which causes it to swing around behind the rider through a turn. The rider may need to be aware of his or her surroundings as the tread could hit an object.

6.3. **General Weather Limitations**

As with any winter vehicle, the risks of travelling in the winter conditions must be taken into consideration. With the addition of the kit design, the bike is more useful; however the user also must be more cautious. The bike with the kit attached should not be expected to perform in any unreasonable circumstances including, but not limited to, travelling down a hill at high speeds (over 15 miles per hour), making sharp (90 degree or greater) turns at high speeds, and unsafe practices. Testing has been done to ensure the system is strong, however the user must be cautious and the Snobike team cannot guarantee safety in extreme circumstances. General safety practices should also be used, including wearing a helmet while riding, being aware of the surroundings, and paying attention to traffic and traffic patterns.
7. **Conclusion**

7.1. **Christian Perspective**

The design project incorporates many of the values that the team, as Christians, hold in high regard. One of the ideals striving for was putting others first. The Snobike kit was created with the user in mind and is designed to keep the user safe. Another idea is to help people in need. Some people completely rely on their bikes for transportation and the Snobike kit helps them to be able to do this year round despite the winter conditions.

7.2. **Design Norms**

7.2.1. **Stewardship**

One of the most important parts of this project is the idea of stewardship, both financially and environmentally. In Genesis, God gave man dominion over the earth, meaning people can use the earth, but they are responsible for its keeping and wellbeing. The mandate from God includes careful use of the earth’s limited resources. The team incorporates stewardship in the kit because it is manually powered and does not use any fossil fuels. Stewardship is also incorporated financially because the Snobike kit is less expensive than a car.

7.2.2. **Trust**

The bicycle design is dependent on the trust of the user. If the user does not trust the design of the bicycle, then they will not use it or be interested in purchasing it. The incorporation of trust into a design makes it dependent and reliable. Trust means avoiding conflicts of interest, no questionable choices or design features that might bring harm to the user.

7.3. **Future Work**

The Snobike kit is a viable product. However, further optimization of the product must be performed before the product could be marketed. Individual improvements could be made to the ski design and the tread design, as well as overall improvements to the kit. With more time and resources, the system could be designed to be more efficient and user friendly. The product line could be expanded to include not only a commuter product (as designed by the team), but also a product that is capable of handling rougher winter terrain. The idea does not need to be limited to winter, but could be expanded to include designs for different types of conditions, soil, and different types of terrain.

7.3.1. **Ski Design**

The design of the ski system has several main points that need further optimization. If the product was going to be marketed, changes would need to be made to the ski design, the upper attachment mechanism, and the attachment to the fender of the bike.
7.3.1.1. Downhill Skis

The skis used in the prototype are downhill skis cut to the proper size. If this design were to be marketed, the skis would be custom made by the production company. They would reflect the general downhill ski design (with the curve upward in the front), however they would be custom designed for the proper length (22.375 inches). The downhill ski design is valuable because the skis are already designed to operate in winter weather conditions. They are useful for cutting into the snow and ice to provide a turning edge. They also provide balance assistance in deep snow. It would be more cost effective to make the skis rather than buy downhill skis and cut them to the proper size.

7.3.1.2. Motion Development

Further development should be done on the upper attachment mechanism. Currently, it is held rigid by the forks that hold the skis in place. If the system was designed to be the most useful the mechanism would be allowed to rotate side-to-side as the bike turned so the skis could fully assist the bike in turning. The level of complexity this design adds to the kit’s simple mechanism was not anticipated by the team and is not designed on this prototype.

7.3.1.3. Clamp

The clamp design to attach the ski mechanism to the fender is not completely universal at this time. The design works with bikes that have a fender attachment, where the brakes are connected, as the clamp can connect to either side. However, on some bikes the fender set-up is different and it is impossible to utilize the clamp design. More development of the clamp would need to be done or the company would need to associate itself with one brand of bikes in order to fully rely on the fender feature.

7.3.1.4. Ski Height Adjustability

The ski height is currently held at a constant 1.75 inches above the ground, which prevents the skis from interfering with operation on pavement. However, when in deep snow, the user might prefer to be able to adjust the height of the skis (in order to have them engage earlier) and may wish to lower them. A system should be designed so that the user could lower the skis closer to the ground. This would provide increased adjustability of the overall system and increased usefulness to the user.

7.3.2. Tread Design

The design of the tread system has a few specific points that need to be optimized before going into production. Since extensive FEA was performed, the amount of material used has been minimized, however, other points, including the usage of the rim of the back tire and the comfort of the rider need to be dealt with before this product goes into production.
7.3.2.1. Tread Requirements

The current tread used in the kit design is an old snowmobile tread, which was useful for prototyping and testing. However, when the kit is actually sold, the company should manufacture a custom tread for the kit. The tread is installed on the rim of the rear tire of the bike, so additional cushioning is needed to prevent the rim from being damaged. This could be accomplished by adding an additional layer of rubber thickness on the tread. In addition to the extra cushion, the teeth on the inside of the tread cannot be as wide. In order to fit into multiple rims on varying bike types, the teeth need to be 0.5” wide instead of the current 0.71” wide.

7.3.2.2. Snow Guard

A minor improvement to the tread system would come in the form of a “snow guard” (similar to a mud flap on a car or truck) that would attach to the shock system on the tread. The snow guard would protect the rider from being splashed by snow that would stick to the tread as it went around the tire. It would prevent the rider from getting wet and cold from the tread system while riding.

7.4. Project Conclusion

7.4.1. Engineering 339 and 340 Conclusion

The Snobike design and prototype project covered the length of an entire school year. The initial part of the project, determining feasibility and achievability, was considered a success in Engineering 339. The actual modeling and prototyping process took place over the course of Engineering 340. The process of design and manufacturing is an extremely important one for engineers, especially young engineers, to learn before heading out into the working world. The entire team learned a lot about many different topics, including working with others, getting tasks done, working in the metal shop, and completing a project.

7.4.2. Acknowledgments

All of the tasks for this project were done with the support of professors, including but not limited to, Mr. Leonard DeRooy, Mr. Ned Nielsen, Dr. J. Aubrey Sykes, and Dr. Steve VanderLeest, as well as the extensive support of Phil Jasperse, Calvin Metal Shop Supervisor, and Dr. Ren Tubergen, the team’s industrial consultant and the donations of Charlie Vallier. Without the knowledge of these people, the project would not have been accomplished with the same degree of success.
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Team 16: Snobike
Business Plan

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5/12/2010
1. Executive Summary

1.1. Company information
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1.3. Brief description
Snobike Industries will be a small privately owned company that produces a bike that will be capable of traveling in the snow. Bikes are used as a common form of transportation but are not adequate for winter use. The Snobike kit will allow a bike to be used in the winter conditions.

1.4. Overview of market
Our market is restricted to the northern parts of the United States and Canada as this is where the Snobike kit is most useful.

1.5. Strategies
The Snobike kit will be priced lower than the competitors. It is also differentiated by the fact that the front ski will be convertible between the tire and the ski, making it more versatile.

1.6. Managerial and Technical experience
The managerial experience of this team comes from four year of technical and project management experience. All four of the team members have gone through the engineering program at Calvin College and have had previous experiences through summer internships.

1.7. Financial requests and purpose
Snobike Industries is asking for a total contribution of $250,000. This money will be put towards initial warehouse rental, salaries, machinery, and materials.

1.8. Tables of financial forecasts
See Appendix 13.1
2. Vision and Mission Statement

2.1. Entrepreneur’s vision for the company

Our vision for Snobike Industries is to create a company that is a leader in manufacturing kits that equip a bike for use year round.

2.2. What business are we in?

Our company, Snobike Industries, will manufacture and sell kits that allow the consumer to transform their ordinary bike into a bike that can ride on pavement or snow. We will be completely responsible for making the product and will sell directly from the Snobike website to the customer. There will also be some distribution channels, such as bike shops and other small retailers.

2.3. Values and Principles

Our company is based in a Christian background, and naturally retains many Christian values. There are three main values and ideas that our company will focus on:

Stewardship: Snobike Industries will manufacture the Snobike kit in a way that will not cause further harm to the environment. This includes refraining from or reducing the use of dangerous chemicals and using energy efficient methods of manufacturing. This will help preserve the environment as well as reduce company costs.

Transparency: This product will be reliable and have an easy to understand design. This will allow the consumer to better understand the underlying mechanisms of the product to provide the greatest level of satisfaction.

Trust: This value is similar to transparency in that the design must be simple to understand. If the consumer better understands how the product functions, they will be better able to trust that product. This also includes making sure the product is safe and that adequate safety instructions are included in the product.

2.4. Uniqueness and Competitive Advantage

Our business is unique in several ways. One way is the main product we sell. There are currently very few kits available that allow a person to equip their bike for winter use. This is not a very large industry as of now, but through the use of marketing and advertising, this industry will begin to grow. This is especially true as people search for cheaper, more energy efficient modes of transportation.

Our competitive advantage is the uniqueness of our product. Even though there are a few small companies that have products to equip a bike for winter use, no company has a product that equips a bike for year round use. Our product has the ability to be used year round, on snow and pavement, without complicated and time consuming modifications. This sets our business and product apart from all others in the market.
3. Industry Profile and Overview

3.1. Industry Analysis

3.1.1. Industry Background and Overview

Currently, the snow-capable bike industry is very small. There are only a few companies that offer products similar to ours. Most companies in this industry have emerged within the past 20 years. This is a relatively new idea, so it is understandable that the industry is small. The industry has been growing in recent years as bike use has risen drastically due to difficult economic times. The industry now is based primarily on sales over the internet or by phone. This is an industry that has yet to move into major retail sectors.

3.1.2. Major Customer Groups

The major customer groups in the snow-capable bike industry can be divided into two distinct groups. The first group is comprised of individuals who use snow-capable bikes for recreation. This group includes those involved in extreme winter sports, snowmobilers, and mountain bikers. This group will mainly use the snow-capable bike in snowy rural areas with possible rugged terrain.

The second major customer group is those that use and rely on bikes as a mode of transportation. This would include individuals who live in urban and suburban areas and are within biking distance of public locals, such as schools, work, stores, entertainment centers, and houses of worship. This customer group will most likely not use the snow-capable bike for recreation, but rather as a cheaper and more environmentally friendly mode of transportation.

3.1.3. Regulatory Restrictions

Currently, there are no regulatory restrictions within the industry. The only restrictions within this industry and every industry are those that result from the patenting of similar products.

3.1.4. Significant Trends

There is a significant expansion trend within the snow-capable bike industry. As more people start using bikes as a main source of transportation, there is an increased demand for products that allow for safe and effective travel through snow. This expansion has resulted from 2 major causes. The first cause is the push for more environmentally friendly modes of transportation. As people become increasingly concerned about the state of our environment, many have used biking as a way to reduce harmful emissions. As the push for environmental care increases, so do the bike industry and snow-capable bike industries. The second cause is the economy. There are countless families in the US and other countries that are suffering from the weak global economy. Many are trying to use bikes as a way of reducing or eliminating fuel and car repair costs. As winter approaches, there will be an increased demand or need for products that allow for safe and inexpensive travel over snow.
3.1.5. Growth Rate

Currently, there are a few companies that are in the market, and their business is growing. As people become more aware of the products available, the industry grows. As mentioned above, there has been significant expansion within the snow-capable bike industry.

3.1.6. Barriers to Entry and Exit

Currently, there are no official government barriers to entry and exit. This business will have barriers similar to those of any simple product manufacturer and distributor. One unofficial barrier to entry is the unique designs that do not violate any current patents on similar products. Another barrier to entry would be the acquisition of startup capital. Most of the money invested in this business will be up front, mostly because of the manufacturing based business model.

3.1.7. Key Success Factors

There are several keys to success in the snow-capable bike industry. One key to success is the production of a durable product. The products in this industry are somewhat expensive, and the end user desires a product that will have good quality and long life. Another key to success is the added features. Since most products in this industry are similar in design, a business that wishes to succeed must provide a product with more features than the product of their competitors. This should also be done with reduced manufacturing costs.

3.1.8. Outlook for the Future

The snow-capable bike industry will continue to grow. As environmental concerns become more and more prevalent, people will turn to bikes and similar modes of transportation to use in their daily lives. This is also true of those who are looking to avoid costly fossil fuels. As these modes of transportation become more and more common, there will be an increased demand for technological improvements that allow the transportation to function year round. As this happens, the snow-capable bike industry will grow.

3.2. Stage of Growth

Currently, the snow-capable bike industry is at a start-up stage. Many people still do not know about the available products for year round bike use. This is mainly due to the industry itself, being comprised primarily of small companies. These small companies do not have the capital or resources to launch a major advertising campaign, and as a result, the products remain relatively unknown.
4. Business Strategy

4.1. Desired Image and Position in the Market

The goal of Snobike Industries is to become the leading company in the snow-capable bike industry. This organization wishes to attain the image of a company that provides a superior, dependable, and competitively priced product.

4.2. Company Goals and Objectives

4.2.1. Operational

There are several operational goals for Snobike Industries. The major operational goal is to produce a dependable, superior, competitively priced product. This will be done by reducing material costs and optimizing our manufacturing processes. Another operational goal is to create a distribution system that can deliver the finished product throughout the United States and Canada. This distribution system will include the entire web sales system, warehouse for stored inventory, and deliveries to small retail stores that will sell the finished product.

4.2.2. Financial

There are two major financial goals for Snobike Industries. The first major goal is to create a profit. Obviously the company cannot survive if it cannot create a profit. This will be done through marketing and reduction of overhead and manufacturing costs. The second financial goal is to reduce profit margins so that more units of the product can be sold. As more units are sold and used, the individual product manufacturing costs are reduced. This helps create a more competitive pricing structure. As more units are used, more people will become aware of the product, and sales will increase.

4.2.3. Other Goals

There are a few goals for Snobike Industries that do not fit in either the financial or operational section. One such goal is to create a product that will ultimately help those who rely on bikes or desire bikes as their main mode of transportation but are trapped by winter weather. This goal will be accomplished by providing a competitively priced product.

4.3. SWOT Analysis

4.3.1. Strengths

Snobike Industries’ strengths rely on its innovative product design and production. The product has been designed to be durable and effective in facilitating bike transportation in winter weather. The bike has also been designed to allow an easy “switch” between snow riding and pavement riding – a design feature that is absent from competitor’s designs. Snobike Industries will also optimize the manufacturing process to produce a competitively priced product.
4.3.2. Weaknesses

The main weakness is the relatively new industry in which Snobike Industries is based. While a competitively priced, durable, superior product is very helpful for sales, no sales can be made if the industry is unknown. As the snow-capable bike industry is still relatively unknown, attracting new customers will require advertising and publicity, which can be expensive.

4.3.3. Opportunities

Snobike Industries has the opportunity to become involved in an industry that will soon take off. By becoming a leading company in the snow-capable bike industry early in its growth, Snobike Industries will be poised to become the leader through much of the initial and rapid growth of the industries. This leadership will cause our company’s name to become synonymous with the snow-capable bike industry.

4.3.4. Threats

One major threat to the company is the possible entrance of a large company into the industry. If a well established company with large sums of startup capital were to produce and market a similar priced product, Snobike Industries would experience major reductions in revenue. Since the large company would have better resources, they could advertise more and produce products that are less expensive than could be produced by a smaller company.

4.4. Competitive Strategy

4.4.1. Cost Leadership

As stated many times in this business plan, Snobike Industries will reduce profit margins in an effort to produce a competitively priced product. With the added reduction of overhead and optimization of manufacturing processes, the cost will be reduced even further.

4.4.2. Differentiation

Product differentiation will be a key to the success of Snobike Industries. Our product will provide the added feature of switching from a tire to skis in a quick and easy manner. This will allow people to ride over both snow and pavement during the same trip without spending a lot of time or carrying special tools to switch between tire and ski.

4.4.3. Focus

The focus of the competitive strategy will be split between quality of product and differentiation. The differentiation in product, as discussed above, will improve Snobike Industries standing over its competitors. The same is true of the quality of product. People have complained about the poor quality of competitor’s products on various web sites. By responding to the user’s needs, we will differentiate ourselves from our competitors.
5. Company Products and Services

5.1. Description

5.1.1. Product Features

The product is a kit that can be attached to a standard mountain bike. This kit will give the bike the ability to be used in snowy winter conditions. This will be accomplished by adding skis to the front and a tread system in the back. The skis will be collapsible for the convenience of the customer. The tread system will be designed for ease of use and ability to push with an appropriate force.

5.1.2. Customer Benefits

When using this product the customer will be able to use their normal mountain bike in the winter with ease. This is incredibly useful to people that rely on a bike as their main source of transportation.

5.1.3. Warranties and Guarantees

There will be a five year warranty for this product. This will give customers confidence. They will know that they can trust the product because it is backed up by a financial promise.

5.1.4. Uniqueness

This product is unique because there is not a product on the market that gives the same results. Some inventors have tried this idea before, but it has not gone to a mass manufacturing level. There is a design for a similar product from Ktrak. This kit, however, is meant for riding down mountains. The Snobike is meant to be used on paths and roads for commuting.

5.2. Patent and Trademark Protection

There are currently only two patents that are similar to our designs. Both patents are through the Canadian Intellectual Property Office. One patent is for the front ski and its patent number is 2496740. The other patent is for the rear tread system and its patent number is 2497365. Our designs do not violate these patents because there are key differences. Also, the patents are currently only through the Canadian Intellectual Property Office. The international patents are still pending.

5.3. Description of Production Process

5.3.1. Raw Materials

The raw materials needed for manufacturing this product are mainly aluminum and rubber. Most of the kit will be made of aluminum and the tread will be made of a hard rubber that is yet to be determined. There will also be some components that will need to be purchased from suppliers. This includes a shock as well as various bolts and fasteners.
5.3.2. Cost

The goal is to make a product that has a higher quality and is less expensive than the competitors. Currently the main competitor has a market price of $529 which gives a manufacturing cost of about $150.

5.3.3. Key Suppliers

Snobike Industries will rely on companies that provide a wide range of services that can meet the Snobike needs. The skis and tread will need to be supplied from out of house whereas the rest will be manufactured in house.

5.3.4. Lead Time

The lead time will be approximately a day. This will be due to our efficient manufacturing processes.

5.4 Future Product and Service Offerings

Snobike is being designed as a kit to be put on average mountain bikes. In the future, work could be done to expand this. One option is that the kit could be adapted to different bike types. This could include road bikes and children’s bikes. Another option is that Snobike could become a full bike instead of a kit. There is a possibility to make a product that could be sold at a competitive price with normal bikes depending on the design changes.
6. Marketing Strategy

6.1 Target market

6.1.1 Problem to be solved

Currently, bikes are not designed to function well in snow. It is unsafe to ride a bike in the slippery conditions. This limits the use of bikes to seasons without snow. Many people rely on bikes as a form of transportation. It is a more viable economic option rather than having to buy a car. The design of a Snobike kit will allow a bike to be used safely year around.

6.1.1.1 Demographic Profile

The demographic profile of a potential customer is mostly limited by location. Snobike’s efforts will be aimed toward the northern part of the United States and Canada. These areas typically have snow during the winter months, and the Snobike will have many useful applications for these customers. There is little need for a Snobike in the southern part of the country as snow is rare. A person may not have certain physical disabilities as they need to be able to ride a bike. Snobike is currently only going to be offered for adult bikes, so a customer will need to be old enough to be able to ride a larger bike. Other factors have little influence on our target market. Race, sex, and education level are minor factors.

6.1.1.2 Customer characteristics

Typical customer characteristics may include someone who enjoys riding a bike, physically in good condition, enjoys the outdoors, and may want to reduce their carbon footprint. College students fit the customer profile well as many students rely on bikes for transportation.

6.1.2 Customer’s motivation to buy

Riding a bike during the winter is much more economical than driving a car. A car requires an initial purchase, insurance, and gas. These costs can accumulate quickly. A Snobike kit is a much more economical option. Similar to the summer, buses may not be a good alternative as they may not be available in a certain area or the bus schedule may not fit in a personal schedule. A Snobike kit is a much more convenient option as it is always available. Bikes do not have any combustion carbon emissions. This reduces a person’s carbon footprint on the world and promotes a greener future.

6.2 Market size and trends

6.2.1 Market size

The market size is about one percent of the population of the United States. This is roughly 3 million people.
6.2.2 Market growth

The market has potential to grow as there is a movement towards a more green economy and way of life. In difficult economic times, this is a great method of reducing cost in your lifestyle.

6.3 Personal selling efforts

6.3.1 Sales force

The sales force will only include one person who will be in charge of relations with the companies that will be resellers of the Snobike. There is no need for recruitment and little need for training.

6.3.2 Sales compensation

The sales person will be compensated with a salary of $20,000 and will be motivated through a 5% commission rate on all sales produced by the sales person. Commission driven sales is needed to help motivate the expansion of our company.

6.4 Advertising and promotion

6.4.1 Media used

Much of the sales will be from the Snobike website. Therefore, other forms of internet advertising will be used to lead potential customers towards the Snobike website. Also, advertisements will be placed in certain city newspapers in the sports section to market towards active people who enjoy outdoor activities. Furthermore, advertisements will be placed in college newspapers as this will focus on the target market.

6.4.2 Media costs

5% of Snobike Industries fixed costs will go towards advertisements and promotions. This is forecasted to be about $10,000

6.4.3 Frequency of usage

The internet advertising has a higher priority than the newspaper advertisements. Internet advertising will be continuous. City newspaper advertising will be mostly used on Sundays with an addition of other days of the week based on available funds. College newspapers will be used weekly.

6.4.4 Discounts

Other publicity actions will be taken. A demonstration may be held at a local ski resort to raise awareness of the Snobike. Test rides will be given to show how functional the Snobike is. Also, competitions will be held at colleges to give away a free Snobike.
6.5 Pricing

6.5.1 Cost structure

Snobike’s cost structure will focus on variable costs. Future changes are unknown so more control over the variability is desired. It is undesirable to purchase large machinery that may not be used.

6.5.2 Desired image in market

It is desirable to have the Snobike as the leading image of new transportation and adventure. So many new opportunities are opened up using a Snobike. The Snobike image should be one of enjoyment and additional bike use.

6.5.3 Comparison to competitor’s prices

The main competitor has their kit priced at $529. The Snobike retail price is set at $475 which is about 10% below the price of the competitor.

6.5.4 Discounts

Discounts for resellers will be given. It will be sold to them at the wholesale price of $350, which will allow them to mark up the price around 75%.

6.5.5 Gross profit margin

The gross profit margin for the first three years is forecasted to be 37%, 55%, and 59% respectively.

6.6 Distribution strategy

The distribution strategy includes a few different channels. The Snobike will be manufactured, assembled, and packaged in house. Distribution and shipping will go directly through the United Parcel Service (UPS). Direct sales from the Snobike website will be shipped to customers through UPS. Orders from resellers will also be delivered to them through UPS.
7. Location and Layout

7.1. Location

7.1.1. Demographic Analysis of Location

This product is aimed at a specific group of people. The Snobike is made for winter conditions and this means that the population in consideration will be living in areas that are hit with snow in the winter. With this in mind, the company will be based out of Grand Rapids, Michigan. This placement puts the company near to a significant portion of its consumers.

7.1.2. Labor Needs and Supply

In order to produce the Snobike, a manufacturing facility will need to be setup. This factory will create many jobs for Michigan workers. Since there are a relatively low number of parts being made, manual labor will be used over automated systems. Material supply will have some costs. Materials such as aluminum and rubber will be shipped to the factory. This may cost more because of the factory’s location, but will be balanced out by the lower amount of product shipment.

7.1.3. Wage Rates

The average factory or plant worker makes about $20/hour. Since this company will rely heavily on manual labor, the pay will keep up with current trends. The employees will be paid an appropriate wage ensuring productive work.

7.2. Layout

7.2.1. Size Requirements

The facilities needed for Snobike Industries will be relatively small compared to most. A building will be rented in the Grand Rapids area that is around 25,000 square feet. An office building will be added in the warehouse in order to facilitate the management and sales needs. This will be relatively small and will be around 5,000 square feet.

7.2.2. Americans with Disabilities Act Compliance

The facilities used fall under Title III of the ADA. These facilities need to be handicap accessible. The ADA has already been effective since 1990, so the rented buildings will already be up to code. Precautions will be taken to follow the ADA when factory machinery is installed.

7.2.3. Ergonomic Issues

Ergonomic issues will be avoided in the office by using appropriate equipment. This includes items such as ergonomic chairs and keyboards. The main ergonomic issue in the factory is due to repetitive tasks. In order eliminate this problem, workers will rotate between jobs. This will reduce the strain on the employees.
8. Competitor Analysis

8.1. Existing Competitors

8.1.1. Existing Competitors

The main competitor is a company located in Canada called Ktrak. They are currently the only competition producing a similar product. There are some major differences between Ktrak and Snobike’s products. Also, the purpose of their bike is to go downhill while the Snobike kit is designed for trail and path riding purposes.

8.1.2. Strengths

The strength of Ktrak lies within its stability. It is already an established company and has been for the past few years. Ktrak also has a name that is well known within its target market.

8.1.3. Weaknesses

The main weakness of Ktrak is the fact that they are not directly competing with Snobike. The two products are very similar, but they are not intended for the same scenarios. Ktrak’s product is intended for riding down mountains through deep snow. Snobike, on the other hand, is intended for transportation on snowy paths and trails.

8.2. Potential Competitors

8.2.1. Potential Competitors

A company that is a potential competitor is a big bike company like Schwinn. Another possible competitor is a large snowmobile company like Polaris.

8.2.2. Competitor Impact

Both of these companies have the ability to be a big threat if they decided to come out with a similar product. First of all, they both have extensive knowledge in their areas and this could make them very successful. Secondly, they are both well established companies that have a lot of resources and assets. Lastly, they both have very recognizable names that are well known and respected.
9. Description of Management Team

9.1. Key Managers and Employees

The key managers and employees of Snobike Industries were brought together their senior year of studies at Calvin College. They will all be graduating with a degree in Engineering and a Mechanical concentration in May of 2010.

9.1.1. Matthew Milan

Raised in Rockford, Michigan, Matthew received his bachelor’s degree from Calvin College. Matthew has a lot of experience writing and implementing business plans and was an obvious candidate for Chief Financial Officer. He works in the accounting department to manage the budget of Snobike Industries. Matthew is also interested in quality control issues. Through statistical control processes, he ensures that all parts of Snobike meet all industrial regulations along with the rigorous company specifications.

9.1.2. Matthew Brouwer

Matthew grew up in Fresno, California and then moved to Michigan to attend Calvin College for his undergraduate work. Matthew enjoyed design work all through college doing his best to understand materials and apply them in new and exciting ways. At Snobike Industries, Matthew is co-design lead along with Justin Karsten. Matthew has a special interest in optimizing all design ideas and working to thoroughly test new ideas that may be applicable to Snobike Industries product line. Along with his work at Snobike Industries, Matthew is pursuing a graduate degree in Engineering Management to increase is knowledge and skill set.

9.1.3. Jennifer Meneely

A Pittsburgh, Pennsylvania native, Jennifer moved out of western Pennsylvania to attend Calvin College in Grand Rapids, Michigan. Jennifer gained experience in project and team management through her various projects and jobs during college, which made her a good fit for Chief Executive Officer at Snobike Industries. In this position, she implements the business strategies of the company and fosters a sense of community and teamwork within the company. She works with the CFO and the COO to maintain a sense of unity throughout the operations at the plant.

9.1.4. Justin Karsten

Justin was raised in Hudsonville, Michigan and spent a lot of time outside snowmobiling and enjoying winter weather. After his undergraduate work at Calvin College, Justin decided to utilize his knowledge of snowmobiles and his talent for working with his hands to join Snobike Industries as co-design lead with Matthew Brouwer. Justin works hard to keep the Snobike product line working efficiently with the latest technologies and advancements. Justin has thrived while working in the factory and assisting in management to operations, which made him the best candidate for Chief Operating Officer in charge of all plant operations that are a part of Snobike Industries.
9.2. Future Additions to the Management Team

Snobike Industries has no immediate plans to add to the management team. However, if the business continues to grow and interest in the product increases as it has in the past year and a half, different options will be considered.

9.3. Board of Advisors

Snobike Industries has employed several outside experts for monitoring and advising of design and management processes within the company. These engineers all have industry experience and are knowledgeable in the various aspects of the product line.

9.3.1. Mr. Ned Nielsen

Mr. Nielsen was the Snobike Project’s first manager, as he was the senior design advisor for Team Snobike. With a vast professional experience and knowledge base, Mr. Nielsen has been an integral part of the design and management process. He helped to set up the initial organizational style of Snobike Industries and has remained a constant aid in design optimization.

9.3.2. Dr. Ren Tubergen

Dr. Tubergen was the original industrial consultant during Snobike Industries initial design phase—taking place during the team’s senior year at Calvin College. He is extremely experienced in industrial design as well as managing companies, as he has managed several companies before. His work with the company on stress analysis and initial design was very useful in developing the original design. He now works with optimization of the product line and has worked some in new product development.

9.3.3. Mr. Robert Medema

The final advisor is Mr. Medema, with a deep base knowledge in company management and accounting, he has been a valuable member of the board. He has worked with the Chief Financial Officer as well as the accountants to establish a flourishing organizational structure and financial plan.
10. Plan of Operation

10.1. Form of Ownership

Snobike Industries has adopted the corporation type structure as its form of ownership. A corporation is a separate legal entity that has its own rights and privileges separate from those that its members have. At Snobike Industries, this means that the company has separate rights from those that are employed there and as such, has different responsibilities.

While Snobike industries will not be a publicly traded company, there will be investors who provide money to the company in order to allow the company to begin producing products. These investors will be repaid their initial investment along with an interest payment which will cover the costs of the investment. Snobike Industries believes this will not only provide the company with the necessary finances to begin business, but also help to spread the name and products of the company.

10.2. Company structure

![Organizational Chart for Snobike Industries]

Figure 1: Organizational Chart for Snobike Industries

10.3. Decision Making Authority

The decision making authority of this company can be found among the board members and the three heads of the company. Jennifer Meneely has the ultimate authority as she is the CEO.

10.4. Compensation and Benefits packages

The compensation and benefits packages will be very comparable to those offered by similar sized engineering and manufacturing firms. They will be reasonable for the size of the company and the work done by the company.
11. Financial forecasts

11.1. See Appendix 13.1 for Excel Spreadsheet

12. Investment Proposal

12.1. Amount requested

The total amount requested to form Snobike Industries is $250,000. This sum is capable of being accumulated from one or many sources depending on proposed offers. This amount will cover all the necessary costs that will allow the company to be established.

12.2. Purpose and uses of funds

The requested funds will fill the required needs to establish Snobike Industries. Initial funds will be used to increase the quality of the Snobike kit by increasing our manufacturing capabilities with new machinery and design. Warehouse space will be rented for use as office space, manufacturing, assembly, and distribution center. Funds will go towards furnishing the warehouse and making it functional by means of remodel work. Information Technology division will be established to build and run our website and manage the organization of incoming purchase orders. Secretaries will be hired to answer customer questions and perform miscellaneous office work. A marketing crew will be hired to design the logo and website for the corporation. A labor force will be hired to manufacture and assemble the Snobike kit and prepare it for shipment. Leadership will also be added to the payroll. Initial funds will also allow the production of the first kits. This will initiate cash flow through sales. Funds will also cover other miscellaneous costs in the startup process.

12.3. Repayment schedule

The return on the investment of the investors will begin at the end of year three. They will be repaid a fourth of their investment at the end of that year as well as their respective fraction of the 15% of the profits of Snobike Industries. The full amount of their investment will be repaid in full in six years—from the opening of Snobike Industries until the end of the sixth year of operation, payment coming at the end of the year.

12.4. Timetable for Implementing Plan and Launching the Business

A timeframe of 6 months has been proposed to launch the business. This is an ambitious goal but can be accomplished through hard work and determination. Research has been done to identify different available warehouses for rent to use as our space. Ideally within 2 weeks after receiving funds, the best fit warehouse could be available for use. A contractor has been contacted and is available to present a bid and begin remodeling shortly after the warehouse is
acquired. The remodel work is minor and so should be completed within 2 months. The needed manufacturing machinery has been chosen but needs to the funding to be purchased. The machinery would be delivered on site within the 6 month timeframe. The interviewing process for employees would require the majority of the time. Many positions need to be filled and a company is much more successful if it is staffed with highly reliable employees. Hiring the Information Technology department takes priority as they need to develop the website to sell the Snobike kit. The warehouse layout should be set up within the first 5 months to ensure the ability of production before orders start arriving. At 6 months the warehouse should be in order to being manufacturing and distributing the online orders. After the corporation is running, a salesman may be hired to contact small retailers in order to establish arrangements with them to be a retailer of Snobike kits.
13. Appendices

13.1. Financial forecasts

**Appendix 13.1.**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sales revenue</strong></td>
<td>450,000</td>
<td>1,012,500</td>
<td>1,417,500</td>
</tr>
<tr>
<td><strong>Variable Cost of Goods Sold</strong></td>
<td>135,000</td>
<td>303,750</td>
<td>425,250</td>
</tr>
<tr>
<td><strong>Fixed Cost of Goods Sold</strong></td>
<td>150,000</td>
<td>150,000</td>
<td>150,000</td>
</tr>
<tr>
<td><strong>Depreciation</strong></td>
<td>35,725</td>
<td>75,515</td>
<td>78,933</td>
</tr>
<tr>
<td><strong>Gross Margin</strong></td>
<td>129,275</td>
<td>483,235</td>
<td>763,318</td>
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<tr>
<td><strong>Variable Operating Costs</strong></td>
<td>90,000</td>
<td>202,500</td>
<td>283,500</td>
</tr>
<tr>
<td><strong>Fixed Operating Costs</strong></td>
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<td>200,000</td>
<td>200,000</td>
</tr>
<tr>
<td><strong>Operating Income</strong></td>
<td>(160,725)</td>
<td>80,735</td>
<td>279,818</td>
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<tr>
<td><strong>Interest Expense</strong></td>
<td>12,500</td>
<td>25,000</td>
<td>21,875</td>
</tr>
<tr>
<td><strong>Income Before Tax</strong></td>
<td>(173,225)</td>
<td>55,735</td>
<td>257,943</td>
</tr>
<tr>
<td><strong>Income tax (40%)</strong></td>
<td>(69,290)</td>
<td>22,294</td>
<td>103,177</td>
</tr>
<tr>
<td><strong>Net Income After Tax</strong></td>
<td>(103,935)</td>
<td>33,441</td>
<td>154,766</td>
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Snobike Industries
### Pro-Forma Statement of Cash Flows

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<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning Cash Balance</td>
<td>-</td>
<td>6,790</td>
<td>15,746</td>
</tr>
<tr>
<td>Net Income After Tax</td>
<td>(103,935)</td>
<td>33,441</td>
<td>154,766</td>
</tr>
<tr>
<td>Depreciation expense</td>
<td>35,725</td>
<td>75,515</td>
<td>78,933</td>
</tr>
<tr>
<td>Invested Capital (Equity)</td>
<td>75,000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Increase (decrease) in borrowed funds</td>
<td>250,000</td>
<td>-</td>
<td>(62,500)</td>
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<tr>
<td>Equipment Purchases</td>
<td>(250,000)</td>
<td>(100,000)</td>
<td>(75,000)</td>
</tr>
<tr>
<td>Ending Cash Balance</td>
<td>6,790</td>
<td>15,746</td>
<td>111,944</td>
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*Assume no change in Accounts Receivable, Inventory or other current assets other than cash; Accounts Payable or other current Liabilities other than Notes Payable; Fixed Assets other than equipment; or Equity Accounts other than Retained Earnings*

### Snobike Industries
Break-Even Analysis

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales revenue</td>
<td>450,000</td>
<td>1,012,500</td>
<td>1,417,500</td>
</tr>
<tr>
<td>Less: Variable Costs:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable Cost of Goods Sold</td>
<td>135,000</td>
<td>303,750</td>
<td>425,250</td>
</tr>
<tr>
<td>Variable Operating Costs</td>
<td>90,000</td>
<td>202,500</td>
<td>283,500</td>
</tr>
<tr>
<td>Total Variable Costs</td>
<td>225,000</td>
<td>506,250</td>
<td>708,750</td>
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<tr>
<td>Contribution Margin</td>
<td>225,000</td>
<td>506,250</td>
<td>708,750</td>
</tr>
<tr>
<td>Less: Fixed Costs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Cost of Goods</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year 1</td>
<td>Year 2</td>
<td>Year 3</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Sold</strong></td>
<td>150,000</td>
<td>150,000</td>
<td>150,000</td>
</tr>
<tr>
<td><strong>Fixed Operating Costs</strong></td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
</tr>
<tr>
<td><strong>Depreciation</strong></td>
<td>35,725</td>
<td>75,515</td>
<td>78,933</td>
</tr>
<tr>
<td><strong>Interest Expense</strong></td>
<td>12,500</td>
<td>25,000</td>
<td>21,875</td>
</tr>
<tr>
<td><strong>Total Fixed Costs</strong></td>
<td>398,225</td>
<td>450,515</td>
<td>450,808</td>
</tr>
<tr>
<td><strong>Income Before Tax</strong></td>
<td>(173,225)</td>
<td>55,735</td>
<td>257,943</td>
</tr>
<tr>
<td><strong>Year 1</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Total Fixed Costs</strong></td>
<td>398,225</td>
<td>450,515</td>
<td>450,808</td>
</tr>
<tr>
<td><strong>Contribution Margin %</strong></td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Break Even Sales Volume</strong></td>
<td>796,450</td>
<td>901,030</td>
<td>901,615</td>
</tr>
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<td><strong>Equipme nt Purchase s</strong></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Equipment Purchases Year 1</strong></td>
<td>250,000</td>
<td>35,725</td>
<td>61,225</td>
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<td><strong>Equipment Purchases Year 2</strong></td>
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<td><strong>Equipment Purchases Year 3</strong></td>
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<td>78,933</td>
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<tr>
<td><strong>MACRS Rates (7-year recovery period)</strong></td>
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<td>0.1749</td>
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<td><strong>Interest Expense:</strong></td>
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<td><strong>Annual interest rate on debt</strong></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Year 1</td>
<td>Year 2</td>
<td>Year 3</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Average debt balance</td>
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<td>250,000</td>
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<tr>
<td>Interest expense</td>
<td>12,500</td>
<td>25,000</td>
<td>21,875</td>
</tr>
</tbody>
</table>
Snobike Assembly Manual
Tread System Assembly

NOTE: You may want a friend to help you.

Below are the parts and numbers for the back tread system. Use these numbers when assembling the tread system.
Step 1: Unpack entire Snobike kit and make sure all parts are present.

Step 2: Remove rear tire from bike. Deflate the tire and remove rubber exterior and tubing, leaving just the rim. Make sure to keep the rubber exterior and tubing for when Snobike kit is removed.

Step 3: Loop the tread around the rear rim. Make sure that the flat end of the ribs, on the bottom of the rim, face away from the bike. Also, make sure that the teeth on the inside of the tread are secure inside the rim.

Step 4: Place the rim and tread component back onto the bike, making sure that the rear tire’s gearing is fully engaged with the chain.

Step 5: Place Part 3 (2) onto the bike by securing ends 3c and 3d to the bike via the rear wheel axle. Make sure that the side 3d goes on the side of the bike that has the gearing system. Tighten the nuts on the axle until both parts are secure.

Step 6: Remove the bike seat. Slip the shock collar (Part 5) onto the bike seat tube. Make sure the thick end is facing toward the front of the bike.

Step 7: Screw in the eye bolt ends of each shock (Part 4) to the bottom screw holes in Part 5. Make sure to use the 1/4” bolt and include a 1/4” washer between the shock and the end of the screw. Tighten each screw securely.

Step 8: Tighten the main bolt and nut in the shock collar (Part 5) until it cannot slide along the bike seat tube. Place the bike seat back on the bike and securely fasten it.

Step 9: Attach the remaining ends of the shock (Part 4) to the shock bars (Part 3b) at the uppermost hole. Make sure the shocks (Part 4) are on the inside of the bars (Part 3b). Tighten using 1/4” nuts.

Step 10: Remove the end nuts from the idler wheel system (Part 1). Make sure all of the washers remain where they are. Place the threaded rods (Part 2) on each end of the axle, making sure the plate side is facing the idler wheels. Place a 3/8” washer on each end, and then place the nuts back on the axle and securely tighten them.

Step 11: Slide the threaded rod / idler wheel combination into the tubes attached to the bike. Make sure the side with the most washers is on the side of the bike with the gearing system.

Step 12: Put a 3/4” nut on each threaded rod, followed by a 3/4” washer.

Step 13: Place the tread around the idler wheel (Part 1), making sure the tread teeth fit snugly between the two idler wheels (Part 1). Tighten the two nuts on the threaded rod (Part 2)
to tighten the tread. Adjust the nuts as needed, making sure that they are lined up with the same marker.

**Step 14:** Place the threaded shock rod (Part 6) through the lower holes on the shock bars (Part 3b). While doing this, make sure there is a lock washer through the rod on each side of each shock bar (Part 3b). Make sure there is a 3/8” nut pressed against each lock washer. Tighten the nuts securely.

The Snobike Tread System is now installed and ready to use!

Continue on to the Ski System Installation Guide.
Ski System Assembly

NOTE: You may want a friend to help you.

Below are the parts and numbers for the Ski System. Use these numbers when assembling the Ski System.
**Step 1:** Unpack entire Snobike kit and make sure all parts are present.

**Step 2:** Remove front tire from the bike. Remove the spacer nuts from the axle of the tire.

**Step 3:** Place the ski mechanism around the tire. Slide the axle into the slots on the tabs (Part 1) of the ski mechanism.

**Step 4:** Position the bike (the front forks) on the axle attached to the ski mechanism, placing the forks between the quick release and the ski mechanism.

**Step 5:** Line the rod (Part 3) up so that the ski mechanism is perpendicular to the ground, and tighten the clamp so the system is securely clamped to the fender of the bike. Tighten the quick release of the axle until secure.

**The ski system is now installed and ready to use!**
## Bill of Materials

<table>
<thead>
<tr>
<th>Part</th>
<th>Item #</th>
<th>Description</th>
<th>Material or Company</th>
<th>Part Cost</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tightening System</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tread</td>
<td>1</td>
<td>1.75 in wide Tread</td>
<td>Rubber</td>
<td>$75.00</td>
<td>1</td>
<td>$75.00</td>
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<tr>
<td>Tube</td>
<td>2</td>
<td>ND= 1 in, L= 48in</td>
<td>304 Stainless Steel</td>
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<td>1</td>
<td>$15.38</td>
</tr>
<tr>
<td>Threaded Rod</td>
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<td>1</td>
<td>$29.19</td>
</tr>
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<td>$4.89</td>
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<tr>
<td>Aluminum Plate</td>
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<td>$12.65</td>
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<tr>
<td>3/4 Washer</td>
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<td>D=0.75in</td>
<td>Steel</td>
<td>$0.19</td>
<td>2</td>
<td>$0.38</td>
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<td>3/4 Nut</td>
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<td><strong>Idler System</strong></td>
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<td></td>
</tr>
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<td>Cast Iron, Rubber Surface</td>
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<td>$51.00</td>
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<tr>
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<td>2</td>
<td>$0.40</td>
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</tr>
<tr>
<td>Steel Bar</td>
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<td>$2.64</td>
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<td>Shock</td>
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<td>Model Number: C16-10788 35 lb</td>
<td>Suspa</td>
<td>$20.00</td>
<td>2</td>
<td>$40.00</td>
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<tr>
<td>Shock: Eye Ends</td>
<td>17</td>
<td>D=0.25in</td>
<td>Suspa: Steel</td>
<td>$1.50</td>
<td>2</td>
<td>$3.00</td>
</tr>
<tr>
<td>Bike Clamp</td>
<td>18</td>
<td>Bike Seat Clamp w/ Luggage Mount</td>
<td>M-Wave</td>
<td>$7.99</td>
<td>1</td>
<td>$7.99</td>
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<td>4</td>
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<td>10mm Ball Stud, Part Number: P67-000008F</td>
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<td>$3.50</td>
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<tr>
<td>1/4 Nut</td>
<td>22</td>
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<td>Steel</td>
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<td>4</td>
<td>$0.80</td>
</tr>
<tr>
<td>1/4 Bolt</td>
<td>23</td>
<td>D= 0.25in, L= 0.5in</td>
<td>Steel</td>
<td>$0.40</td>
<td>2</td>
<td>$0.80</td>
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<tr>
<td>1/4 Washer</td>
<td>24</td>
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<td>Steel</td>
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<td>2</td>
<td>$0.38</td>
</tr>
<tr>
<td>1/4 Bolt</td>
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<td>D=0.25in, L=1.25in</td>
<td>Steel</td>
<td>$0.40</td>
<td>2</td>
<td>$0.80</td>
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**Tread Total**  $262.24
<table>
<thead>
<tr>
<th>Part</th>
<th>Item #</th>
<th>Description</th>
<th>Material or Company</th>
<th>Part Cost</th>
<th>Quantity</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ski System</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downhill Skis</td>
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<td>L=22.375 in</td>
<td>Steel and Fiberglass</td>
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<td>$20.00</td>
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<td>Aluminum Block</td>
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<td>L= 6 in, W= 3 in, H= 1 in</td>
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<td>$12.45</td>
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<tr>
<td>Aluminum Dowel</td>
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<td>6061-T4 Aluminum</td>
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<td>$0.25</td>
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<tr>
<td>1/4 Nut</td>
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<td>Steel</td>
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<td>2</td>
<td>$0.40</td>
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<td>Square Tube</td>
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<td>W= 1 in, h= 1 in, twall= 0.13 in, L= 57 in</td>
<td>6061-T4 Aluminum</td>
<td>$23.94</td>
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<td>U-Channel</td>
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<tr>
<td>3/8 Nut</td>
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<td>D= 0.375 in</td>
<td>Steel</td>
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<td>$0.40</td>
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<td>3/8 Washers</td>
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<td>$1.90</td>
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<td>3/8 Bolt</td>
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<td>L= 4.5 in, W= 1 in, t= 0.2 in</td>
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<td><strong>Kit Total</strong></td>
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Tab Hand Calculations

Inputs

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<tr>
<td>P&lt;sub&gt;x&lt;/sub&gt;        </td>
<td>40 lbf</td>
<td>(Horizontal Force)</td>
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<tr>
<td>P&lt;sub&gt;y&lt;/sub&gt;        </td>
<td>300 lbf</td>
<td>(Vertical Force)</td>
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<tr>
<td>h        </td>
<td>0.35 in</td>
<td>(smallest height in part)</td>
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<tr>
<td>b        </td>
<td>0.25 in</td>
<td>(width of base)</td>
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<tr>
<td>L        </td>
<td>1.2 in</td>
<td>(length of part)</td>
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<tr>
<td>K&lt;sub&gt;t&lt;/sub&gt;        </td>
<td>1.8</td>
<td>(Stress Concentration Factor: Found in a Table)</td>
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<tr>
<td>E        </td>
<td>10000000 psi</td>
<td>(Modulus of Elasticity for Aluminum)</td>
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<tr>
<td>ν        </td>
<td>0.33</td>
<td>(Poisson's Ratio for Aluminum)</td>
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Stress & Strain Calculations

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<tr>
<th>A&lt;sub&gt;xc&lt;/sub&gt;       </th>
<th>0.0875 in&lt;sup&gt;2&lt;/sup&gt;</th>
<th>(XC Area)</th>
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<td>σ&lt;sub&gt;x&lt;/sub&gt;       </td>
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<tr>
<td>σ&lt;sub&gt;y&lt;/sub&gt;       </td>
<td>6171.428571 psi</td>
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<tr>
<td>ε&lt;sub&gt;x&lt;/sub&gt;       </td>
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<tr>
<td>ε&lt;sub&gt;y&lt;/sub&gt;       </td>
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<tr>
<td>ε&lt;sub&gt;z&lt;/sub&gt;       </td>
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<tr>
<td>σ&lt;sub&gt;p1&lt;/sub&gt;       </td>
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<tr>
<td>σ&lt;sub&gt;p2&lt;/sub&gt;       </td>
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<tr>
<td>Δ&lt;sub&gt;x&lt;/sub&gt;       </td>
<td>-0.00014565 in</td>
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<td>Δ&lt;sub&gt;y&lt;/sub&gt;       </td>
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<tr>
<td>Δ&lt;sub&gt;z&lt;/sub&gt;       </td>
<td>-5.7703E-05 in</td>
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Equations

\[
\sigma = \frac{P}{A_{xc}} * K_t \\
\varepsilon_x = \frac{1}{E}(\sigma_x - \nu \sigma_y) \\
\varepsilon_y = \frac{1}{E}(\sigma_y - \nu \sigma_x) \\
\varepsilon_z = \frac{1}{E} \nu (\sigma_x + \sigma_y) \\
\sigma_{p1,p2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2} \\
\Delta = \varepsilon L
\]

Response to Changing Loads

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<th>P&lt;sub&gt;y&lt;/sub&gt; (lbf)</th>
<th>σ&lt;sub&gt;x&lt;/sub&gt; psi</th>
<th>σ&lt;sub&gt;y&lt;/sub&gt; psi</th>
<th>σ&lt;sub&gt;p1&lt;/sub&gt; psi</th>
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Shock System Calculations

"Shock System Calculations"

"Inputs"

Angle = 59[deg]

Shock = 35[lbf]

"Fixed"

L_Attach_idler = 35[in]

L_Attach_wheel = 9[in]

"Calcs - stuff out"

F_down = Shock * sin(Angle)

F_across = Shock * cos(angle)

F_Down * L_Attach_wheel = (L_attach_wheel + L_attach_idler) * F_IdlerWheel

F_IdlerWheel_total = 2 * F_IdlerWheel

"Solution"

F_across=18.03 [lbf]

F_down=30 [lbf]

F_IdlerWheel=6.137 [lbf]

F_IdlerWheel_total=12.27 [lbf]